Basemap modified from U.S. Geological Survey DRG

(rubber-sheeted to dimensions of paper quadrangle copy)

Bon Air quadrangle, Virginia, 1964, Revised 1994

Projection: Modified UTM, NAD 1927 Datum

Digital Cartography by Mark W. Carter

CROSS SECTION A - A'

CROSS SECTION B - B

GEOLOGIC REFERENCE

GEOLOGIC MAP OF THE BON AIR QUADRANGLE, VIRGINIA

MARK W. CARTER, C.R. BERQUIST JR., AMY K. BONDURANT, AND HEATHER A. BLEICK,

Additional data compiled from Bruce K. Goodwin (1980)

SCALE 1:24000

CONTOUR INTERVAL 10 FEET

DASHED LINES REPRESENT HALF INTERVAL CONTOURS

NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology mapped from August 2005 to December 2006

1000 0 1000 2000 3000 4000 5000 6000

1 0.5 0

DESCRIPTION OF MAP UNITS

SURFICIAL UNITS Modified Land¹ – Extensive anthropogenic cut and/or fill related to grading and excavation. Widespread modified land in heavily urbanized areas not shown. Holocene. Variable thickness.

Alluvium¹ – Floodplain deposits ranging from clay to gravel. Holocene to Pleistocene. Variable thickness. Carolina Bays1 - Elliptical depressions filled with 5- to 10-feet (1.5- to

3.0-meters) of massive, brownish-gray silty clay with scattered rounded quartz pebbles, and surrounded by a low ridge or rim of fine-grained sand. All but one occur on the upland surface underlain by high-level Tertiary gravels (Tg1) in the southwestern part of the quadrangle; the other occurs above sand and gravel of the Tertiary upper Chesapeake Group (Tcu) in the southeastern part of the quadrangle. Very similar to, and interpreted to be Carolina Bays of the central and southern outer Atlantic Coastal Plain (Goodwin and Johnson, 1970). Quaternary-Tertiary Alluvial and Colluvial Valley Fill - Channel fill and

side-slope deposits of alluvium and colluvium in drainageways, at elevations ranging from 150- to 200-feet above present sea level. Variably lithified pebbly feldspathic sand, which is very light-gray to pinkish-gray to yellowish-gray, fineto medium-grained quartz and feldspar sand characterizes sediments of the unit. The unit is highly indurated to lithified. Subangular to well-rounded pebbles, cobbles, and boulders of quartz, quartzite (many containing the trace fossil Skolithos), and granite are scattered throughout. The matrix contains very few mica minerals. Feldspar is variably weathered to clay, which, with hematite, carbonate, and silica, contributes to cementation. One sample consists of about 41.5% quartz, 3% plagioclase, 6% potassium feldspar, 23% sericite and clay minerals, 22.5% hematite, 0.5% ilmenite/magnetite, and 3.5% carbonate. In thin section, hematite concretions are common. Locally bedded; gravel beds consist of well-rounded, clast-supported pebbles and cobbles. Basal gravel lag deposit, up to about 1-foot- (0.3 meter-) thick, typically occurs at the contact with underlying Paleozoic granite, and is commonly iron-oxide cemented (ferricrete). Lithification distinguishes this unit from younger Holocene to Pleistocene surficial alluvium, and is also generally higher in elevation. The unit is interpreted to be remnants of periodic debris flows that mixed granite saprolite with reworked gravels from older or more distal units. Pliocene to Pleistocene. Maximum thickness about 10-feet (3-meters).

COASTAL PLAIN UNITS

Quaternary-Tertiary Gravels - Gravel and sand deposits that occur on low hills at elevations of about 120 feet above present sea level in the vicinity of the confluence of Powhite Creek and James River (in the central-eastern part of the quadrangle). Rounded quartz and quartzite pebbles and cobbles, most with the trace fossil Skolithos, make up the unit. May correlate with at least part of the lower Pleistocene to upper Pliocene Windsor Formation (Coch, 1968) downstream along James River (Mixon and others, 1989). Maximum thickness

Low-Level Tertiary Gravels - Gravel and sand deposits that cap hills at elevations ranging from 130- to 160-feet above present sea level along both banks of James River and Powhite Creek. Rounded quartz and quartzite pebbles, cobbles, and boulders, many with the trace fossil Skolithos, make up the gravel. Commonly, the base of the unit is lithologically similar to Quaternary-Tertiary alluvial and colluvial valley fill (QTac). Correlates with at least part of the upper Pliocene Bacons Castle Formation (Coch, 1965) to the east (Mixon and others, 1989; Carter and others, 2007). Maximum thickness about 20-feet (6-meters).

Mid-Level Tertiary Gravels¹ - Gravel and sand deposits that cap hills and mantle slopes at elevations ranging from about 200- to 240-feet above present sea level. Gravel consists of rounded quartz and quartzite pebbles, many containing the trace fossil Skolithos, in a sandy to clayey sand matrix, locally stained and unit is lithologically similar to Quaternary-Tertiary alluvial and colluvial valley fill (QTac). A suite of samples consist of about 45% quartz, 22.7% sericite and other clay minerals, 17.2% hematite, 10.2% potassium feldspar, 3.2% plagioclase, 1.8% carbonate, with traces of biotite, muscovite (both as detrital grains) and ilmenite/magnetite. In thin section, feldspar is variably weathered to clay, which, with hematite, carbonate, and possibly silica, contributes to cementation; hematite concretions are common, with few composite grains. Overlies, and slightly younger than upper Chesapeake Group sediments (Tcu), and interpreted to have been deposited during Pliocene sea-level regression. Maximum thickness about 50-feet (15-meters).

Upper Chesapeake Group Sand and Gravel¹ - Grayish-yellow to moderate reddish-brown silty sand and gravel occurs on the low, relatively flat topographic surface along the eastern edge of the quadrangle, to an average elevation of about 245-feet above present sea level (up to 260-feet above present sea level in the southeastern part of the quadrangle). Fine sand with scattered, rounded quartz granules and pebbles is the dominant lithology. Locally, sand is finely laminated, cross-bedded, or bedded with gravel stringers and layers, up to several feet (about 1 meter) thick. Gravel consists of well-rounded, clast-supported quartz and quartzite pebbles and cobbles. Iron-oxide mottling and cement (ferricrete) is common. Base of unit is locally lithologically similar to Quaternary-Tertiary alluvial and colluvial valley fill (QTac). In the southeastern part of the quadrangle, the base is a laminated clayey sand. Fine (pea-size) gravel typically mantles the surface, distinguishing this unit from the Tg1.3 and QTg4 gravels that typically contain coarser cobbles and boulders. Overlies, and younger than high-level Tertiary gravels (Tg₁). This unit is interpreted to have been deposited in fluvial, nearshore, and strandline environments (Daniels and Onuschak, 1974; Goodwin, 1980). Most likely correlates with the Pliocene upper Chesapeake Group, as the nearshore equivalent of the down-dip marine Yorktown Formation (Newell and Rader, 1982). Maximum thickness about 20-feet (6-meters).

High-Level Tertiary Gravels¹ – Gravel and sand deposits that cap hills in the eastern half of the quadrangle and underly the relatively flat upland topographic surface in the southwestern part of the quadrangle at elevations ranging from 250 to 350 feet above present sea level. Yellowish-brown to reddish-brown sediment consists of abundant, well rounded pebbles and cobbles in a sandy to clayey sand matrix; gravel composition dominantly vein quartz and quartzite (a few clasts contain the trace fossil Skolithos), with few metamorphic and igneous clasts; quartzite clasts commonly deeply weathered to decomposed; partially iron-oxide cemented (ferricrete) matrix; locally bedded. Commonly, the base of unit is lithologically similar to Quaternary-Tertiary alluvial and colluvial valley fill (QTac). Unconformably overlies lower Chesapeake Group sediments (Tcl), and interpreted to have been deposited during Miocene to Pliocene sea-level regression. Maximum thickness about 50 feet (15 meters).

> Lower Chesapeake Group Clayey Silt - Dark greenish-gray to medium bluish-gray (weathers moderate yellowish-brown) clayey silt unconformably underlies gravel and sand (Tg₁) in the southwestern part of the quadrangle. This unit contains clay, silt, and very fine-grained sand; subangular to subrounded quartz granules and abundant mica flakes are common within the finer-grained matrix. Iron-oxide mottling and staining from disseminated iron sulfide is common. Massive to finely laminated; locally bedded with gravel stringers, up to about 3-inches (approximately 8-centimeters) thick, consisting of well-rounded, clast-supported quartz pebbles; sparsely fossiliferous; locally jointed. Easternmost exposures consist of gravish yellow to gravish orange, finely laminated sandy silt. Basal gravel lag deposit, up to about 1-foot- (0.3-meter-) thick, locally occurs at the unconformable contact with the underlying Paleozoic Petersburg Granite. The gravel lag consists of clast-supported, subangular to well-rounded pebbles, cobbles, and boulders of quartz and granite; commonly iron-oxide cemented (ferricrete). Where gravel is not present, the basal lithology consists of fine- to medium-grained quartz and feldspar sand. Unit interpreted to be estuarine to marine. Maximum thickness about 18-feet (5.5-meters) in the headwaters of Powhite Creek.

CATACLASTIC ROCKS

Silicified Cataclasite¹ – White to very light-gray brecciated quartz is the dominant rock type of this unit. Quartz fragments range from pebble- to cobble-size; fractures and voids between fragments filled with botryoidal masses. concentric growths, and vugs of drusy quartz crystals. One sample consists of about 97.5% quartz, 1.5% hematite, 1% muscovite, and traces of biotite and zircon. Slickensides are common on some fracture surfaces. Fragments of country rock are also common within brecciated quartz locally. Silicified cataclasite is resistant to weathering and erosion, and occurs as outcrops or abundant float that caps many hills within the outcrop belt. Also included within this unit are zones of intensely fractured country rock, cross-cut by abundant swarms of approximately 0.1-inch- (2.5-millimeters-) thick chalcedony- and quartz-filled joints and fractures. In these zones, granule- to boulder-size fragments of country rock dominate. Locally, chalcedony- and quartz-filled fracture swarms grade into thicker zones of brecciated quartz. Several silicified cataclasite zones portrayed on the geologic map are exaggerated, and many more observed are too small to map separately at this scale. Age of formation and deformation of at least one silicified cataclasite zone is well constrained in the north-central part of the quadrangle. Here, a 2-foot- (0.6 meter-) thick silicified cataclasite cross-cuts and brecciates Jurassic diabase. Deformation along other silicified cataclasite zones (mostly in the central-western part of the quadrangle) is potentially much younger - at several localities, reactivated silicified cataclasite zones appear to offset Tertiary units.

IGNEOUS INTRUSIVE ROCKS

Diabase¹ – Dark-green to black, weathers to dark reddish-brown; aphanitic to fine-grained; occurs as dikes ranging from several feet to about 10-feet (1- to 3-meters) thick; commonly weathers to spheroidically rounded, dense boulders or punky cobbles that can be traced along strike when outcrop is absent. Easily distinguished from older mafic gneiss (mg) by non-foliated texture and lack of metamorphic overprint. Several dikes portrayed on the geologic map are exaggerated for clarity, and several more dikes observed are too small to map separately at this scale. Jurassic. NEWARK SUPERGROUP

Newark Supergroup, Undivided¹ - Sandstone, shale, and coal in the Mesozoic Tuckahoe sub-basin occurs along the western edge of the quadrangle. Sandstone is very pale-orange to brownish-gray to brownish-black (weathers to moderate vellowish-brown to dusky vellowish-brown); medium- to coarse-grained, locally granule conglomeratic to pebble conglomeratic; arkosic, micaceous, and carbonaceous. One sample consists of about 53.5% quartz, 5.5% plagioclase, 17.5% potassium feldspar, 18.5% sericite, 3% biotite, 1% epidote, 1% carbonate, and traces of muscovite, chlorite, hematite and zircon. Shale is brownish-black to dusky-red (weathers to moderate reddish-brown); laminated to thin bedded; fossiliferous. Both rock types locally interbedded with thin seams of black coal. Unconformably overlies Paleozoic Petersburg Granite, but contacts are not well exposed, and are locally faulted. Newark Supergroup (Froelich and Olsen, 1984) rocks on the quadrangle correlate with the "lower barren beds" of Heinrich (1878). Upper Triassic. Thickness on the Bon Air quadrangle greater than 150

IGNEOUS INTRUSIVE ROCKS

PETERSBURG GRANITE

feet (45 meters).

Ashland in Hanover County to the north, to Dinwiddie in Dinwiddie County to the south. Its outcrop belt is bounded to the north and west by the Richmond-Taylorsville Mesozoic basins, and is covered by Coastal Plain sediments to the south and east. Dated at approximately 330 MA (Mississippian) by Wright and others (1975), and approximately 315 MA (Pennsylvanian) by Lee and Williams (1993). On the Bon Air quadrangle, the Petersburg Granite is subdivided into four phases, from youngest to oldest:

The Petersburg Granite underlies a large region of east-central Virginia, from near

Subidiomorphic Granite¹ – Light bluish-gray; fine- to medium-grained, locally coarse-grained; homogenous, uniform subidiomorphic texture; locally foliated. One sample consists of 37.5% quartz, 24% potassium feldspar, 15% plagioclase, 12% muscovite, 6% biotite, 3% epidote, 1.5% hornblende, 0.5% zircon, 0.5% carbonate, and traces of ilmenite/magnetite, apatite and garnet. Locally porphyritic, with pale-pink potassium feldspar phenocrysts less than 0.5-inch (1-centimeter) in length; locally contains pods, lenses, zones, and enclaves of foliated granite and layered granite gneiss; cross-cut by aplite and pegmatite dikes; well jointed.

Porphyritic Granite¹ - Grayish-blue, medium- to coarse-grained, porphyritic granite, with pale-pink potassium feldspar phenocrysts over 1-inch (2.5-centimeters) in length, commonly oriented and aligned subparallel to a weak to strong biotite foliation within the matrix. Composed of about 31% potassium feldspar, 25.5% quartz, 20.5% plagioclase, 18% biotite, 2.5% epidote, 1% muscovite, 1% zircon, 0.5% carbonate, and traces of hornblende, hematite, and ilmenite/magnetite. Quartz and plagioclase dominate the matrix; quartz is typically medium-gray to light bluish-gray; locally, potassium feldspar phenocrysts deformed to porphyroclasts; commonly associated with coarse- to very coarse-grained medium-gray to light bluish-gray quartz and pale-pink potassium feldspar pegmatite, which also cross-cut older phases; also cross-cut by grayish-yellow aplite dikes; locally contains pods and lenses of subidiomorphic granite, and rarely, layered granite gneiss and foliated granite; well jointed.

Foliated Granite - Light bluish-gray granite; medium- to coarse-grained, locally fine-grained; weakly to strongly foliated. Phyllosilicate and quartz-feldspar alignment defines foliation; unit locally contains pods, lenses, zones, and enclaves of layered granite gneiss, subidiomorphic granite, and rarely porphyritic granite; cross-cut by aplite and pegmatite dikes; well jointed.

Layered Granite Gneiss - Light bluish-gray to medium bluish-gray to medium-gray granite; compositionally layered; layering ranges from 0.5-inch to several inches (1-centimeter to 1-decimeter) thick; composition ranges from quartz-feldspar- to biotite-quartz-feldspar-rich layers; individual layers are fineto coarse-grained, subidiomorphic to locally porphyritic (potassium feldspar phenocrysts are less than 0.5-inch, or 1-centimeter in length); unit locally contains pods, lenses, zones and enclaves of subidiomorphic granite and foliated granite; cross-cut by aplite and pegmatite dikes; well jointed.

METAMORPHIC ROCKS

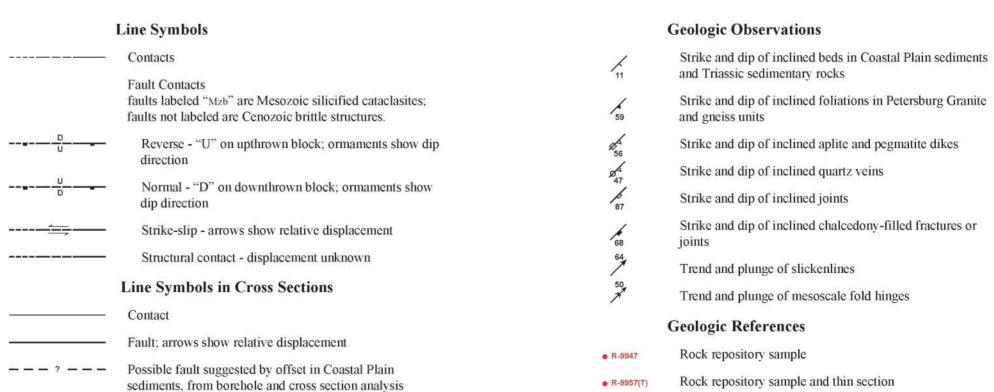
Felsic and mafic metamorphic rocks occur as enclaves, xenoliths, or possibly roof pendants¹ within Petersburg Granite. These rocks are older than Petersburg Granite, but maximum age constraints are lacking. Larger bodies are shown on the geologic map; several more bodies were observed, but are too small to map separately at this scale.

Felsic Gneiss¹ – Biotite-muscovite granitic gneiss; compositionally layered rock consisting of constrasting quartz-feldspar- and phyllosilicate-rich layers, 0.5-inch- (1-centimeter-) thick. Quartz-feldspar-rich layers are bluish-white to yellowish-gray; medium- to coarse-grained; granoblastic to locally porphyroclastic. Phyllosilicate-rich layers are medium dark-gray to dusky-brown to very dusky-red; fine- to medium-grained; lepidoblastic; strongly foliated.

Mafic Gneiss - Muscovite-biotite gneiss, amphibole-biotite gneiss and schist, amphibolite and talc-amphibole schist. These rocks range from dark-gray to dark greenish-gray to dusky yellowish-green to olive-gray to dusky yellowish-brown; fine- to medium-grained; lepidoblastic to nematoblastic to locally granoblastic. One sample of talc-amphibole schist consists of 44.5% actinolite/tremolite, 38% orthopyroxene (as relict grains), 6.5% talc, 5.5% chlorite, 4.5% ilmenite/magnetite, 0.5% biotite, 0.5% carbonate, and a trace of plagioclase. Interlayered locally with felsic gneiss, described above. Easily distinguished from younger diabase (Jd) by foliation and metamorphic overprint.

MAP SYMBOLS

For all line symbols: lines are solid where the location is exact (located in field to within 50-feet, or 15-meters), long-dashed where the location is approximate (located to within 200-feet, or 60-meters); short-dashed where the location is inferred. For geologic observation symbols, observation sites are centered on the strike bar, or are at the intersection point of multiple



(structures not shown on the geologic map) Form line of foliation or eroded contact

Commodity letter symbol precedes identification number (identification numbers are preceded by "127D-" in Mineral Resources of Virginia database). Commodity letter symbols: bs - building and dimension stone; c - coal2; cs - crushed stone; fill - saprolite or earth material; sg - sand and gravel

Subsurface structures interpreted from surface measurements

Abandoned or reclaimed prospect Abandoned or reclaimed borrow pit Abandoned or reclaimed mine or quarry

For all cross-sections:

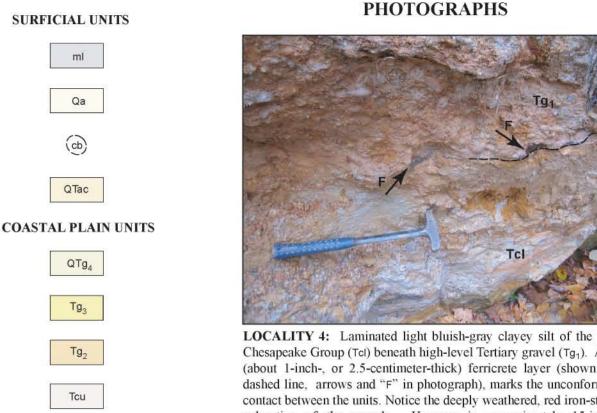
Mineral Resources

Rock repository sample and thin section Rock repository sample and geochemical analysis

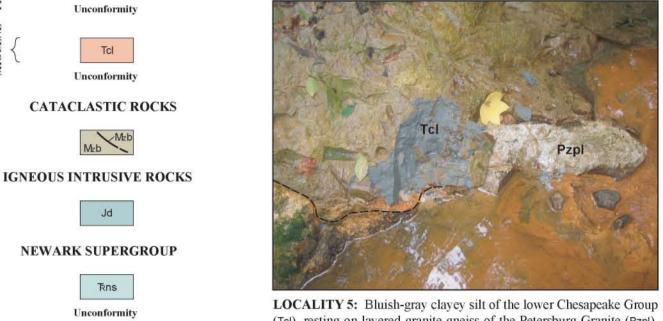
Rock repository sample with both thin section and geochemical analysis Water well drill cuttings

Other boreholes used to construct map and cross sections Location of geologic reference photograph (location at tip of arrow)

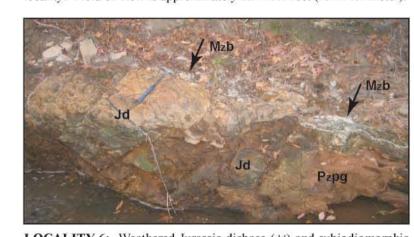
CORRELATION OF MAP UNITS



Chesapeake Group (Tcl) beneath high-level Tertiary gravel (Tg₁). A thin (about 1-inch-, or 2.5-centimeter-thick) ferricrete layer (shown by a dashed line, arrows and "F" in photograph), marks the unconformable contact between the units. Notice the deeply weathered, red iron-stained coloration of the gravels. Hammer is approximately 15-inches-(38-centimeters-) long.



(Tcl), resting on layered granite gneiss of the Petersburg Granite (Pzpl). The unconformable contact with granite is undulatory (marked by a dashed line in the photograph), but a basal gravel lag is absent at this locality. Field of view is approximately 2.5 x 3.5 feet (0.7 x 1.0 meter).



LOCALITY 6: Weathered Jurassic diabase (Jd) and subiodiomorphic granite (Pzpg) cross-cut, truncated, and brecciated by a thin (1-foot, or 0.3-meter-thick) silicified cataclasite zone (marked by arrows and "Mzb" in the photograph). Jurassic or younger age for this silicified cataclasite is indicated by outcrop relationships. Hammer is approximately 15-inches- (38-centimeters-) long.



IGNEOUS INTRUSIVE ROCKS

PETERSBURG GRANITE

LOCALITY 1: Subidiomorphic phase of the Petersburg Granite. Notice the small (up to 0.75-inch, or 2-centimeters) potassium feldspar phenocrysts (marked by an arrow and "P" in the photograph). Matrix consists of quartz and plagioclase. Pencil is about 4-inches- (1-decimeter-) long.

GEOLOGIC REFERENCE

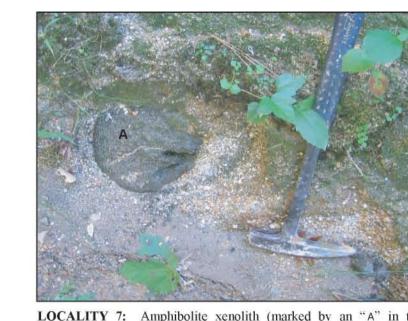
PHOTOGRAPHS



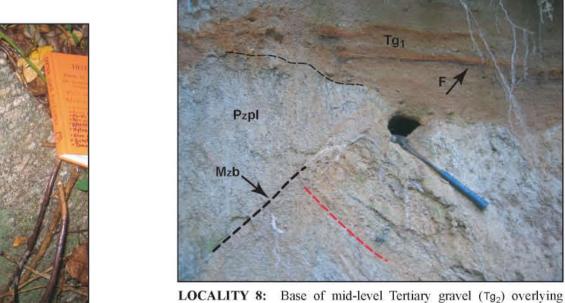
LOCALITY 2: Porphyritic phase of the Petersburg Granite. Notice the large (up to 1.5-inches or 4-centimeters) potassium feldspar phenocrysts (marked by an arrow and "P" in the photograph). Edge of fieldbook is about 7.5-inches- (19-centimeters-) long.



LOCALITY 3: Basal gravel lag deposit at the base of mid-level Tertiary gravel (Tg2). Subidiomorphic phase of the Petersburg Granite (Pzpg), left and above hammerhead, underlies gravel along the contact shown by a dashed line. Lithified pebbly feldspathic sand above the gravel lag are lithologically similar to Quaternary-Tertiary alluvial and colluvial valley fill. Hammerhead is about 8-inches- (2-decimeters-) long.



LOCALITY 7: Amphibolite xenolith (marked by an "A" in the photograph) in layered granite gneiss of the Petersburg Granite. Faint layering can be seen in the granite, between the hammerhead and the xenolith. Hammer is approximately 15-inches- (38-centimeters-) long.



layered granite gneiss of the Petersburg Granite (Pzpl). The contact is marked by a thin dashed line in the photograph. Mid-level Tertiary gravel sediments appear to thicken slightly at a thin silicified cataclasite zone (marked by a thick dashed line and "Mzb" in photograph). The sediments were either deposited along an exposed silicified cataclasite zone, or were faulted with slight offset along the reactived silicified cataclasite. There is no offset in ferricrete layers above the contact (ferricrete layers are marked by an arrow and "F" in photograph). Layering in Petersburg Granite is marked by a red dashed line in the photograph. Hammer is approximately 15-inches- (38-centimeters-)

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report be made in the following form: Carter M.W., Berquist, C.R., Jr., Bondurant, A.K., and Bleick, H.A., 2007, Geologic map of the Bon Air quadrangle, Virginia: Virginia Division of Mineral Resources, Open-File Report 07-03, map scale 1:24,000.

Division of Mineral Resources. It is recommended that reference to this

FOOTNOTES

¹Description of map unit modified from Goodwin (1980). ²Approximate location of the coal prospect in the northwest quarter of the quadrangle from Shaler and Woodworth (1899).

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20x vertical exaggeration